AQA

Please write clearly in block capitals.

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I declare this is my own work.

AS MATHEMATICS

Paper 2

Friday 23 May 2025 Afternoon Time allowed: 1 hour 30 minutes

Materials
- You must have the AQA Formulae for A-level Mathematics booklet.
- You should have a graphical or scientific calculator that meets the requirements of the specification.

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer each question in the space provided for that question.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do **not** write outside the box around each page or on blank pages.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

For Examiner's Use	
Question	Mark
1	
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Section A

Answer **all** questions in the spaces provided.

1 A curve C has equation

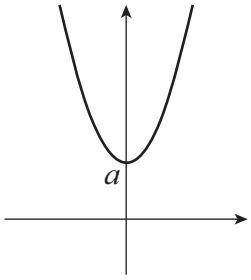
$$y = (x + a)^2$$

where a is a positive constant.

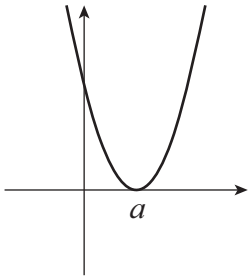
Identify which **one** of the graphs represents C

Tick (✓) **one** box.

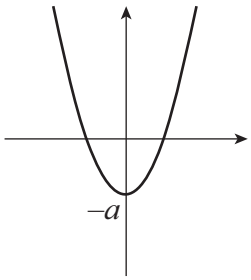
[1 mark]



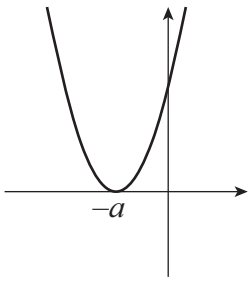
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2 Given that

$$f'(x) = 3x^2$$

Find $f''(x)$

Circle your answer.

[1 mark]

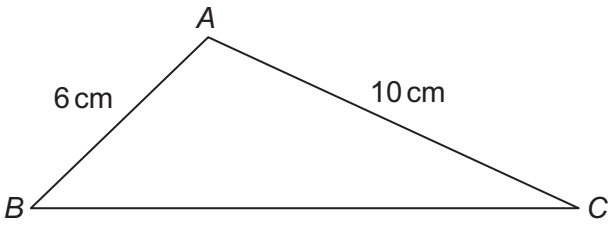
6 $6x$ x^3 $1.5x^3$

Turn over for the next question

Do not write outside the box

3 *ABC* is the cross-section of a triangular prism.

The length of *AB* is 6 cm and the length of *AC* is 10 cm as shown in the diagram.



The prism has length 20 cm and volume 500 cm^3

Find the size of the obtuse angle *CAB*

Give your answer to the nearest degree.

[4 marks]

Area of cross-section = 500 ÷ 20 = 25 cm^2

$\frac{1}{2} \times 6 \times 10 \times \sin A = 25$

$30 \sin A = 25 \Rightarrow \sin A = \frac{5}{6}$

$\sin^{-1}\frac{5}{6} = 56.442...°$

Obtuse angle CAB = 180° − 56.442...° = 123.557...°

Angle CAB = 124° (nearest degree)

Do not write outside the box

4 The equation of the line L is

$$2x + 3y = 24$$

4 (a) Find the gradient of L

[1 mark]

$3y = 24 - 2x \Rightarrow y = 8 - \frac{2}{3}x$

Gradient of $L = -\frac{2}{3}$

4 (b) Point A has coordinates $(2, -2)$ and point B has coordinates $(10, p)$, where p is an integer.

The line L is the perpendicular bisector of the line AB

4 (b) (i) Find the value of p

[3 marks]

Gradient of $AB = -1 \div (-\frac{2}{3}) = \frac{3}{2}$

$\frac{p - (-2)}{10 - 2} = \frac{3}{2}$

$p + 2 = 12$

$p = 10$

4 (b) (ii) Find the coordinates of the point of intersection of AB and L

[1 mark]

Midpoint of $AB = (\frac{2 + 10}{2}, \frac{-2 + 10}{2}) = (6, 4)$

Check: $2(6) + 3(4) = 24$ ✓ so L meets AB at $(6, 4)$

Do not write outside the box

5 Use the substitution

$$u = 4^x$$

to solve the equation

$$16(4^{2x}) - 33(4^x) + 2 = 0$$

[4 marks]

$4^{2x} = (4^x)^2 = u^2$

$16u^2 - 33u + 2 = 0$

$(16u - 1)(u - 2) = 0$

$u = \frac{1}{16}$ or $u = 2$

$4^x = \frac{1}{16} = 4^{-2} \Rightarrow x = -2$

$4^x = 2 \Rightarrow 2^{2x} = 2^1 \Rightarrow 2x = 1 \Rightarrow x = \frac{1}{2}$

$x = -2$ or $x = \frac{1}{2}$

Do not write outside the box

6 Solve the simultaneous equations

$$x = 2y - 11$$

$$y = 2x^2 - 4x + 1$$

Fully justify your answer.

[4 marks]

Substitute y into $x = 2y - 11$:

$x = 2(2x^2 - 4x + 1) - 11$

$x = 4x^2 - 8x + 2 - 11$

$0 = 4x^2 - 9x - 9$

$(4x + 3)(x - 3) = 0$

$x = 3$ or $x = -\frac{3}{4}$

When $x = 3$: $y = 2(3)^2 - 4(3) + 1 = 18 - 12 + 1 = 7$

When $x = -\frac{3}{4}$: $y = 2(\frac{9}{16}) - 4(-\frac{3}{4}) + 1 = \frac{9}{8} + 3 + 1 = \frac{41}{8}$

Check in $x = 2y - 11$: $2(7) - 11 = 3$ ✓, $2(\frac{41}{8}) - 11 = \frac{41}{4} - \frac{44}{4} = -\frac{3}{4}$ ✓

Solutions: $x = 3, y = 7$ and $x = -\frac{3}{4}, y = \frac{41}{8}$

Do not write outside the box

7 It is given that

$$f(x) = 3x^2 + 3x - 8$$

7 (a) Express $f(x)$ in the form

$$a(x + b)^2 + c$$

where a, b and c are constants to be found.

[3 marks]

$f(x) = 3(x^2 + x) - 8$

$= 3[(x + \frac{1}{2})^2 - \frac{1}{4}] - 8$

$= 3(x + \frac{1}{2})^2 - \frac{3}{4} - 8$

$= 3(x + \frac{1}{2})^2 - \frac{35}{4}$

$a = 3, \quad b = \frac{1}{2}, \quad c = -\frac{35}{4}$

7 (b) (i) State the minimum value of

$$3\sin^2\theta + 3\sin\theta - 8$$

[1 mark]

$3\sin^2\theta + 3\sin\theta - 8 = 3(\sin\theta + \frac{1}{2})^2 - \frac{35}{4}$ and $\sin\theta = -\frac{1}{2}$ is possible

Minimum value $= -\frac{35}{4}$

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7 (b) (ii) Find the smallest positive value of θ for which this minimum value occurs.

[2 marks]

Minimum when $\sin\theta + \frac{1}{2} = 0 \Rightarrow \sin\theta = -\frac{1}{2}$

$\sin^{-1}(-\frac{1}{2}) = -30°$

$\theta = 180° - (-30°) = 210°$

Smallest positive value: $\theta = 210°$

Turn over for the next question

Do not write outside the box

8 Find the coordinates of the minimum point of the curve with equation

$$y = x^3 - 5x^2 - 8x + 2$$

Fully justify your answer.

[8 marks]

$\frac{dy}{dx} = 3x^2 - 10x - 8$

For stationary points $\frac{dy}{dx} = 0$:

$3x^2 - 10x - 8 = 0$

$(3x + 2)(x - 4) = 0$

$x = -\frac{2}{3}$ or $x = 4$

$\frac{d^2y}{dx^2} = 6x - 10$

When $x = 4$: $\frac{d^2y}{dx^2} = 6(4) - 10 = 14 > 0 \Rightarrow$ minimum

When $x = -\frac{2}{3}$: $\frac{d^2y}{dx^2} = 6(-\frac{2}{3}) - 10 = -14 < 0 \Rightarrow$ maximum

When $x = 4$: $y = 4^3 - 5(4)^2 - 8(4) + 2$

$= 64 - 80 - 32 + 2 = -46$

Minimum point is $(4, -46)$

Do not write outside the box

9 It is given that

$$\int_1^3 f(x)\,dx = 8$$

9 (a) Write down the value of $\int_1^3 2f(x)\,dx$

[1 mark]

2 × 8 = 16

9 (b) Write down the value of $\int_1^3 (f(x) + 2)\,dx$

[1 mark]

8 + 2 × (3 − 1) = 8 + 4 = 12

9 (c) Write down the value of $\int_2^4 f(x - 1)\,dx$

[1 mark]

Translation 1 unit right, limits shift from 1 to 3 into 2 to 4: 8

Turn over for the next question

Do not write outside the box

10 (a) Show that

$$\frac{1}{\sqrt{k}+\sqrt{k+1}} \equiv \sqrt{k+1}-\sqrt{k} \qquad k>0$$

[2 marks]

$\frac{1}{\sqrt{k}+\sqrt{(k+1)}} \times \frac{\sqrt{k}-\sqrt{(k+1)}}{\sqrt{k}-\sqrt{(k+1)}}$

$= \frac{\sqrt{k}-\sqrt{(k+1)}}{(\sqrt{k})^2-(\sqrt{(k+1)})^2}$

$= \frac{\sqrt{k}-\sqrt{(k+1)}}{k-(k+1)} = \frac{\sqrt{k}-\sqrt{(k+1)}}{-1}$

$= \sqrt{(k+1)}-\sqrt{k}$ as required

10 (b) Using the result from part **(a)** find the exact value of

$$\frac{1}{\sqrt{1}+\sqrt{2}}+\frac{1}{\sqrt{2}+\sqrt{3}}+\frac{1}{\sqrt{3}+\sqrt{4}}$$

Fully justify your answer.

[2 marks]

Using (a) with k = 1, 2 and 3:

$= (\sqrt{2}-\sqrt{1})+(\sqrt{3}-\sqrt{2})+(\sqrt{4}-\sqrt{3})$

$= \sqrt{4}-\sqrt{1}$

$= 2-1$

$= 1$

Do not write outside the box

11 The equation

$$x^2 + (2k - 1)x + 4 - 2k = 0$$

has two distinct real roots.

Find the range of possible values for k

[4 marks]

Two distinct real roots $\Rightarrow$ $b^2 - 4ac > 0$

$(2k - 1)^2 - 4(1)(4 - 2k) > 0$

$4k^2 - 4k + 1 - 16 + 8k > 0$

$4k^2 + 4k - 15 > 0$

$(2k + 5)(2k - 3) > 0$

Critical values: $k = -\frac{5}{2}$, $k = \frac{3}{2}$

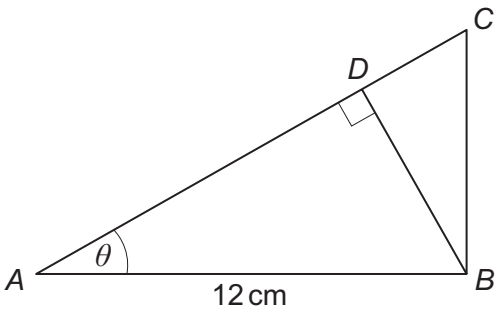
Positive quadratic, so it is > 0 outside the critical values:

$k < -\frac{5}{2}$ or $k > \frac{3}{2}$

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12 In the triangle ABC, the length of $AB = 12$ cm and the angle ABC is a right angle.

The point D lies on AC such that BD is perpendicular to AC as shown in the diagram.



12 (a) Show that $AC = \dfrac{12}{\cos\theta}$

[1 mark]

In right-angled triangle ABC: $\cos\theta = \frac{AB}{AC} = \frac{12}{AC}$

$\Rightarrow \quad AC = \frac{12}{\cos\theta}$

12 (b) Write down an expression for AD in terms of $\cos\theta$

[1 mark]

In triangle ABD: $\cos\theta = \frac{AD}{12} \quad \Rightarrow \quad AD = 12\cos\theta$

12 (c) Hence show that $CD = \dfrac{12 - 12\cos^2\theta}{\cos\theta}$

[2 marks]

$CD = AC - AD = \frac{12}{\cos\theta} - 12\cos\theta$

$= \frac{12}{\cos\theta} - \frac{12\cos^2\theta}{\cos\theta}$

$= \frac{12 - 12\cos^2\theta}{\cos\theta}$

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12 (d) It is given that $CD = 8\sqrt{3}$ cm

Find the value of θ

Give your answer to the nearest degree.

Fully justify your answer.

[5 marks]

$\frac{12 - 12\cos^2\theta}{\cos\theta} = 8\sqrt{3}$

$12 - 12\cos^2\theta = 8\sqrt{3}\cos\theta$

$12\cos^2\theta + 8\sqrt{3}\cos\theta - 12 = 0$

$3\cos^2\theta + 2\sqrt{3}\cos\theta - 3 = 0$

$\cos\theta = \frac{-2\sqrt{3} \pm \sqrt{(12 + 36)}}{6} = \frac{-2\sqrt{3} \pm 4\sqrt{3}}{6}$

$\cos\theta = \frac{\sqrt{3}}{3}$ or $\cos\theta = -\sqrt{3}$

$\cos\theta = -\sqrt{3}$ is not valid since $-\sqrt{3} < -1$

So $\cos\theta = \frac{\sqrt{3}}{3}$

$\theta = \cos^{-1}\frac{\sqrt{3}}{3} = 54.7356...°$

$\theta = 55°$ (nearest degree)

Turn over for Section B

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Section B

Answer **all** questions in the spaces provided.

13 The table shows the favourite sport of a group of students from years 12 and 13.

	football	**rugby**	**netball**	**tennis**	**Total**
Year 12	57	30	36	2	125
Year 13	33	11	19	12	75
Total	90	41	55	14	200

A student is chosen at random.

Find the probability that the student chosen is a year 12 student whose favourite sport is netball.

Circle your answer.

[1 mark]

(0.18) 0.275 0.288 0.44

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14 The events A and B are independent.

It is given that $P(A) = 0.25$ and $P(B) = 0.6$

Find the value of $P(A \cap B)$

Circle your answer.

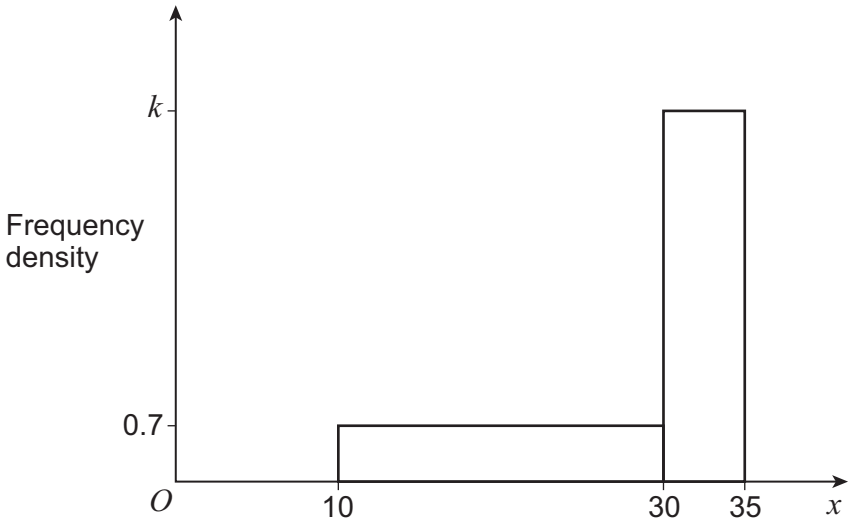
[1 mark]

0 | 0.15 | 0.35 | 0.85

Turn over for the next question

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15 The diagram shows part of a histogram illustrating the distribution of a variable x



The frequency density for the class $10 < x \leq 30$ is 0.7

The frequency density for the class $30 < x \leq 35$ is k

The frequency for the class $30 < x \leq 35$ is double the frequency for the class $10 < x \leq 30$

Find the value of k

[2 marks]

Frequency for $10 < x \leq 30 = 20 \times 0.7 = 14$

Frequency for $30 < x \leq 35 = 2 \times 14 = 28$

$5k = 28$

$k = \frac{28}{5}$ $(= 5.6)$

Do not write outside the box

16 The table shows the probability distribution for a discrete random variable X

x	0	1	2	3	4
$\mathbf{P}(X = x)$	$0.2 - p$	$0.05 + 3p$	$4p$	$2p$	$2p$

Find the value of the constant p

[2 marks]

Sum of probabilities = 1:

$0.2 - p + 0.05 + 3p + 4p + 2p + 2p = 1$

$0.25 + 10p = 1 \Rightarrow 10p = 0.75$

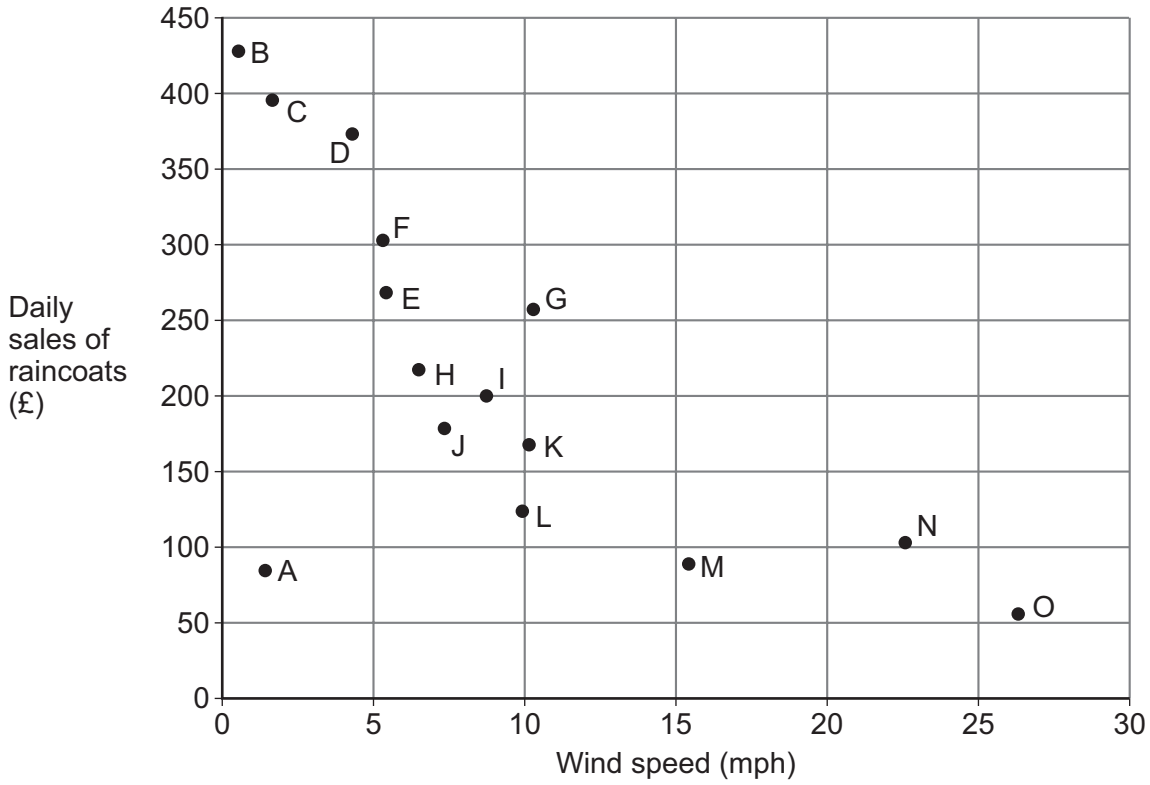
$p = 0.075$

Turn over for the next question

Do not write outside the box

17 The owner of a shop recorded the average daily wind speed in mph and the total sales of raincoats in pounds over a period of 6 months.

The data from a random selection of 15 days from the 6-month period is shown in the scatter diagram.



One of the points on the scatter diagram is an outlier.

17 (a) State the letter from the diagram which corresponds to this outlier.

[1 mark]

A

17 (b) State the effect on the numerical value of the correlation coefficient if the outlier was removed from the data.

[1 mark]

The correlation coefficient would become more negative (stronger negative correlation).

Do not write outside the box

17 (c) Describe, in context, the correlation indicated by the scatter diagram.

[1 mark]

Negative correlation: the higher the wind speed, the lower the daily sales of raincoats.

17 (d) The owner of the shop claims that the scatter diagram proves that windier days cause lower sales of raincoats.

Comment on the validity of this claim.

[1 mark]

The claim is not valid.

Correlation shown on a scatter diagram cannot prove causation; there could be another factor causing the lower sales, e.g. the amount of rainfall on those days.

Turn over for the next question

Do not write outside the box

18 It is known that 3% of the batteries sold in a supermarket are faulty.

Batteries are sold in packs of 12.

It can be assumed that the number of faulty batteries in a pack can be modelled by a binomial distribution.

18 (a) State **one** assumption, in context, necessary for the binomial distribution to be valid.

[1 mark]

Whether one battery is faulty is independent of whether any other battery in the pack is faulty.

18 (b) A pack of batteries is chosen at random.

Find the probability that exactly one battery in this pack is faulty.

[1 mark]

$X \sim B(12, 0.03)$: $P(X = 1) = 12 \times 0.03 \times 0.97^{11}$

$= 0.257508\ldots = 0.258$ (3 s.f.)

18 (c) A quality control supervisor tests 10 randomly chosen packs for faulty batteries.

Find the probability that at least two of the chosen packs have exactly one battery which is faulty.

[2 marks]

Y = number of packs with exactly one faulty battery

$Y \sim B(10, 0.257508\ldots)$

$P(Y \geq 2) = 1 - P(Y \leq 1)$

$= 1 - (0.742491\ldots^{10} + 10 \times 0.257508\ldots \times 0.742491\ldots^{9})$

$= 1 - 0.227532\ldots = 0.772467\ldots$

$= 0.772$ (3 s.f.)

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19 The table represents the frequency distribution of the CO_2 emissions, x g/km of all of the electric and electric/petrol BMW cars in the Large Data Set that were registered in the South-West in 2016.

x	0	13	45	49	77	78
Frequency	1	2	3	9	2	2

19 (a) State the number of electric cars in the distribution.

[1 mark]

1 ($x = 0$ g/km, no CO_2 emitted)

19 (b) Find the mean of the CO_2 emissions.

[1 mark]

$\Sigma f = 19, \quad \Sigma fx = 912$

Mean $= 912 \div 19 = 48$ g/km

19 (c) Find the standard deviation of the CO_2 emissions.

[1 mark]

$\Sigma fx^2 = 52048$

$\sigma = \sqrt{\left(\frac{52048}{19} - 48^2\right)} = 20.8654... = 20.9$ g/km

19 (d) Explain why it is **not** valid to compare the results from part **(b)** and part **(c)** with the mean and standard deviation of the CO_2 emissions of the electric and electric/petrol BMW cars in the Large Data Set that were registered in the South-West in **2002**.

[1 mark]

There were no electric or electric/petrol cars registered in 2002 in the Large Data Set, so there is no data to compare.

Turn over ▶

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20 An office worker has to pass through four sets of traffic lights when driving to work.

If a set of lights is red, the driver has to stop.

The probability that each set of lights is red when the office worker arrives at them is given by

$$P(\text{set 1 is red}) = 0.54$$
$$P(\text{set 2 is red}) = 0.6$$
$$P(\text{set 3 is red}) = 0.7$$
$$P(\text{set 4 is red}) = 0.8$$

Assume that the event that a light is red is independent of whether the other lights are red.

20 (a) Find the probability that the office worker is stopped at all four sets of lights.

[1 mark]

$0.54 \times 0.6 \times 0.7 \times 0.8 = 0.18144$

$= 0.181$ (3 s.f.)

20 (b) Find the probability that the office worker is stopped at **exactly one** of the four sets of lights.

[3 marks]

P(exactly one red)

$= 0.54 \times 0.4 \times 0.3 \times 0.2$ (only set 1 red)

$+ 0.46 \times 0.6 \times 0.3 \times 0.2$ (only set 2 red)

$+ 0.46 \times 0.4 \times 0.7 \times 0.2$ (only set 3 red)

$+ 0.46 \times 0.4 \times 0.3 \times 0.8$ (only set 4 red)

$= 0.01296 + 0.01656 + 0.02576 + 0.04416$

$= 0.09944$

$= 0.0994$ (3 s.f.)

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21 The organiser of a music concert claimed that 80% of the people who attended the concert had an 'excellent' experience.

To test this claim, a random sample of 60 people who attended the concert were asked about their experience, and 42 described it as 'excellent'.

Investigate, at the 5% level, whether there is evidence that the proportion of people who had an 'excellent' experience at the concert is less than the organiser's claim of 80%

[5 marks]

p = proportion of people who had an 'excellent' experience

H_0: $p = 0.8$

H_1: $p < 0.8$

X = number in the sample who had an 'excellent' experience

Under H_0, $X \sim B(60, 0.8)$

$P(X \leq 42) = 0.042697\ldots = 0.0427$

$0.0427 < 0.05$, so the result is significant: reject H_0

There is sufficient evidence at the 5% level to suggest that the proportion of people who had an 'excellent' experience at the concert is less than the organiser's claim of 80%.

END OF QUESTIONS

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